Duplicating has plates on figures

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES ON THE SPILLWAY AND STILLING-BASIN FOR THE ALAMOGORDO DAM--CARLSBAD PROJECT, NEW MEXICO

Hydraulic Laboratory Report No. Hyd.-243

RESEARCH AND GEOLOGY DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

MAY 25, 1948

CONTENTS

	Page
Summary	1
Introduction	2
The Model	3
Stilling-basin Studies	3
Effect of Steps and Sills on Location of Jump	4
Effect of the Apron Design on the Side Eddy	5
Effect of Apron Design on Riverbed Erosion	5
Recommended Stilling-basin Design	5
Spillway Studies	6
Entrance	6
Crest and Spillway	6
Spillway Crest Calibration	7
Model-prototype Comparison	7

FOREWORD

Hydraulic model studies for the design of the Alamogordo Dam Spillway and Stilling-pool were made by H. G. Dewey during the early part of 1936. Due to the pressure of work, the final report was not published until 1948. Construction of the dam began in 1936, and was completed in December 1937, after about 2 years of work.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Branch of Design and Construction
Research and Geology Division
Denver, Colorado

May 25, 1948

Laboratory Report No. 243
Hydraulic Laboratory
Tests by: H. G. Dewey, Jr.
Written by: E. J. Rusho
Reviewed by: A. J. Peterka

Subject: Hydraulic model studies on the spillway and stilling-basin for the Alamogordo Dam--Carlsbad Project, New Mexico.

SUMMARY

In the design of the Alamogordo Dam Spillway, special problems were encountered in securing suitable spillway flow and efficient energy dissipation in the stilling-basin over the entire range of discharge. This report describes the studies made to develop a structure fulfilling these requirements.

In the tests on the open channel spillway, the major portion of the study was devoted to the stilling-basin, four designs being investigated. With each basin several sill and step designs were studied. Tables 1, 2, and 3 summarize these tests. The designs were evaluated from the appearance and location of the jump and from the scour in the river channel. The use of steps and sills was found to be advantageous since they both caused the jump to move upstream in the stilling-basin. Higher steps resulted in a more upstream position of the jump. Higher sills also produced the same result. Movement of the Rehbock sills up or downstream caused a like movement of the jump. Rectangular sills placed at intermediate positions in the stilling-basin were found to be unsatisfactory.

All steps and end sills tested improved the operation of the stilling-basin, with those of greater height being the most effective. The recommended basin design, Figure 5E, with a length of 124 feet 8 inches, used Step E and Rehbock Sill F9, Figures 6 and 7. The training-walls were the same length as the stilling-basin floor. The height of the downstream portion of the walls was 5 feet greater than the original design and the remaining upstream portion 1 foot greater. This increase was necessary because of waves in the stilling-basin. Fillets were used along all wall and floor intersections and extended upstream into the lower section of the chute. Riprap was found necessary for the riverbed and sloping banks downstream from the pool to prevent erosion by the flow leaving the stilling-basin. Other features of the spillway were unchanged from the original design except that longer piers, Figure 16B, were recommended.

The original spillway entrance design was considered satisfactory. Some disturbance to the flow was caused by the spoil bank at the upstream end of the left side of the entrance channel, but the bank was not eroded by the action of the water. Flow over the spillway crest was uniform, but in the chute downstream from the piers, the water surface was roughened from the effects of three fins. Two pier designs were investigated, Figure 16. The longer pier produced some improvement in the flow down the chute. Spillway calibration was made for free flow over the crest, Figure 18, and water-surface profiles, Figure 17, were taken throughout the length of the spillway section.

Since completion of the model studies, opportunities have been found to observe and photograph the prototype spillway at flows up to 42,000 second-feet. The photographs show good agreement between model and prototype in the appearance of the water surface at the spillway entrance, in the spillway chute, and in the stilling-basin, Figures 19 and 20. The action of the stilling-basin in dissipating energy has proven satisfactory in the prototype, demonstrating the value of the model studies.

INTRODUCTION

The dam, located in New Mexico, Figure 1, is a rolled earth embankment structure faced with rock riprap. The major dimensions, Figure 2, are: crest length 1,600 feet, maximum height 149 feet, and thickness at base 1,150 feet. The purpose of the dam is to control the seasonal floods of the Pecos River and to provide additional storage of water to supplement that of the Avalon and McMillan Reservoirs for irrigation of lands under the Carlsbad Irrigation District. The reservoir capacity is 157,000 acre-feet with reservoir elevation 4275 feet.

An open-channel spillway and an outlet works provide for discharge of water from the reservoir. The outlet works, for release of irrigation water, consists of two 54-inch needle valves discharging into a stilling-basin. Water is supplied to the valves by a tunnel through the base of the dam. The spillway, Figure 3, is located at the right or west abutment. It is concrete-lined with a horizontal stilling-basin at the lower end. Flow is controlled by three 21- by 45-foot steel radial gates. Maximum capacity of the spillway is 56,000 second-feet with reservoir elevation 4279.7 feet.

Hydraulic model studies were required for solution of the problems presented in the design of the spillway and stilling-basin. These tests were necessary because various features of flow, particularly the performance of the stilling-basin, could not be evaluated by other means. The studies were made using a 1 to 64 scale model of the spillway portion of the dam. Flow, representative of prototype operation, was observed in the model for several suggested designs. The efficiency of the stilling-basin in dissipating energy was judged, in part, by the erosion of the river channel which was reproduced in coarse gravel. The design which produced the best operation in the model, was recommended for construction in the field.

THE MODEL

The model, Figure 4, built to a scale of 1 to 64, included the spillway and entrance, the stilling-basin, and a portion of the river channel downstream from the basin. The spillway crest was made of concrete screeded to metal templates and was attached to one end of a wooden headbox lined with sheet iron. A wooden chute connected the crest to the tailbox which contained the stilling-basin and a portion of the river channel. The tailbox, steps, sills, and basin were of wood construction. Sand and gravel were used to reproduce the river channel downstream from the stilling-basin. Model discharges were measured by a V-notch weir and point gages were used to determine the reservoir and tailwater elevations.

In the construction of the model, the total vertical fall of the spillway chute was increased by 16 feet, prototype. This was necessary to overcome the greater friction loss in the model resulting from excessive model roughness, since with a small scale model it is not possible to make the model smooth enough to represent the prototype surface. The resulting increased slope compensated for the greater model losses, thus providing the proper velocity and consequently the proper energy for the flow entering the stilling-basin.

STILLING-BASIN STUDIES

In the investigation of the stilling-basin extensive tests were run to obtain a design resulting in satisfactory energy dissipation with the most economical structure. Five basic stilling-basin designs were studied, differing only in length of floor or training-walls. In the original stilling-basin, Figure 5A, the length of the apron floor and right training-wall was 135 feet, the length of the left training-wall was 125 feet, and the floor was at elevation 4118. In the second design, Figure 5B, the length of the apron floor was 167 feet while the training-wall lengths remained as in the original design. The third stilling-basin, Figure 5C, had training-walls and apron floor of equal lengths, 135 feet. In the fourth design, Figure 5D, the length of the apron floor was 135 feet and the length of the training-walls was 124 feet 8 inches. Fillets were added to the corners of the pool formed by the floor and side walls and in the corners of the chute upstream from the steps. The final stilling-basin, Figure 5E, had apron floor and training-walls 124 feet 8 inches in length, fillets were the same as in the previous design.

Various step and sill designs, Figures 6 and 7, were investigated with the different stilling-basins and the tests are summarized in Tables 1, 2, and 3. These tables show the step and sill combinations used in each test and summarize the results.

For the maximum spillway discharge of 56,000 second-feet, normal tailwater was at elevation 4163. The tailwater versus discharge curve is shown in Figure 18. This tailwater curve does not agree with the present rating curve of the gaging station downstream from the dam, but it served satisfactorily for the model studies and was the best available at the time of the tests.

Three criteria were used in judging the stilling-basin efficiency: (1) location of the jump in the basin; (2) depth of scour in the river channel; and (3) intensity of side eddy in the dead water area of the river channel between the end of the stilling-basin and the left riverbank. The effect of the sill, step, and basin designs on these criteria are discussed under separate headings.

Effect of Steps and Sills on Location of Jump

It was found that steps located at the upstream end of the stilling-basin resulted in the jump forming farther upstream. Tests 1, 2, and 3, Table 1, were made without sills at the downstream end of the pool. The Steps A, B, and C used in these tests, Figure 6, demonstrated that higher steps caused a more upstream jump location. The model preparatory for Test 1 is shown in Figure 9. In this test the start of the jump formed just downstream from the steps, Figure 10A, and the water surface was very rough. Scour, Figure 10B, was excessive near the end of the apron.

In Tests 4 through 22, Steps A, C, D, and E were used with end sills at the downstream end of the stilling-basin. The relation of step height to jump location was found to be the same with the sill as without. In Test 8, Steps F alternated with Steps D were unsatisfactory since they formed a nearly solid step which deflected the jet off the apron floor causing the jump to be too far downstream. Spreaders, Figure 8, in the chute, Test 9, contributed little to the performance of the stilling-basin.

Tests 3 through 22 employed various end sills, Figure 7. The double letter sill designations in Tables 1, 2, and 3 refer to sills made up of two parts. For example, in Test 4, Sill A1 resulted from placing Sill A on rectangular Sill 1.

As with the steps the higher sills moved the jump farther upstream. Two sill locations were investigated, one 120 feet downstream from the steps and the other 110 feet downstream. The upstream sill position moved the jump upstream 10 feet farther than the downstream position indicating that the jump location varied directly with the sill position. Test 13, Figures 11 and 12A, gave a fairly satisfactory jump location, but the intermediate rectangular sills in Test 14, Figure 12B, were unsatisfactory since the jump was unstable and too high.

The tests demonstrated that use of steps with the end sill caused the jump to move upstream, with Step E and Sill F10, Test 22, Figures 13 and 14, being the most effective.

Effect of the Apron Design on the Side Eddy

In Tests 1 through 9 with the original apron design, a large eddy was present between the left riverbank and the end of the stilling-basin. Sills at the downstream end of the apron reduced the eddy somewhat, probably because of the lower velocity at the end of the apron. Extension of the left training-wall to 135 feet in the third stilling-basin design reduced the eddy to negligible proportions. Shortening the training-walls to 124 feet 8 inches caused an increase in the eddy velocity, but higher steps and sills corrected this condition by moving the jump upstream. Thus, two of the factors influencing the eddy were the length of the left training-wall and the position of the jump.

Effect of Apron Design on Riverbed Erosion

The erosion of the riverbed was observed for the tests indicated in Tables 1, 2, and 3. With the original apron design without sills, the scour was heavy, Figure 10B. The right riverbank was of sheet metal and remained intact, but the left bank of sand was completely washed away. There was also a tendency to undermine the end of the apron.

Sills at the downstream end of the basin reduced the scour by moving the jump upstream into the stilling-basin. Higher sills resulted in less scour. The upstream sill position gave less scour than the downstream position since the jump was farther upstream. Since the side eddy contributed to the riverbed erosion its reduction by the use of sills or longer left training-wall also reduced the overall scour.

In Test 13, the entire river channel was reproduced with coarse gravel, Figure 11A. Scour was slight with this design, Figure 11B, since the end sills and longer left training-wall resulted in very little side eddy and lower velocities in the river channel and also because of heavy gravel.

Recommended Stilling-basin Design

The effects of the parts of the stilling-basin on its overall efficiency was used to determine the recommended design. This stilling-basin, Figure 5E, used Step E with a height of 8 feet and Sill F10 with a height of 10 feet. The sill was located 110 feet downstream from the steps. Use of the high steps and sills with the sill in an upstream position, made possible a relatively short stilling-basin, 124 feet 8 inches in length.

In the final tests, sheet metal was again used to represent the right riverbank as shown in Figure 13A. The jump location and stilling-pool action were satisfactory. Figure 13B shows operation at 28,000 second-feet with corresponding tailwater elevation 4157.2 feet. After one and one-fourth hours of operation at this discharge the photograph, Figure 14A, was taken. Resulting erosion was slight. Scour showed some increase after 1 hour operating at 56,000 second-feet, Figure 14B, but was still satisfactory.

With the recommended stilling-pool design, water-surface profiles were taken at maximum discharge with tailwater elevation 4163, Figure 15. Riverbed topography was also measured after 75 and 150 minutes of model operation at maximum discharge of 56,000 second-feet. These results are also plotted on Figure 15.

SPILLWAY STUDIES

Entrance

Flow in the entrance channel of the spillway was investigated in the model. Of primary concern in this section was the spoil bank, Figure 2, on the left side of the upstream end of the entrance channel. To determine the effect of the velocity of approach on the stability of the bank, it was modeled with gravel of a size believed to be representative of the prototype material and tested for a discharge of 56,000 second-feet. Continued operation at this maximum discharge did not produce measurable bank erosion, indicating the original design to be satisfactory in this respect. The water surface was rough at the upstream end of the bank, but became smooth before reaching the crest of the spillway. Flow at the right bank of the entrance channel was smooth and the original design was recommended without alterations.

Crest and Spillway

Studies on the spillway crest with the original pier design, Figure 16A, showed flow over the crest to be smooth, but downstream from the piers the water surface became rough with a greater concentration of flow in the central portion of the chute. The rough water surface was made up of three fins which formed at the beginning of the steep section of the chute. From the appearance of the water surface it was believed the piers contributed to the fin formation.

A longer pier, Figure 16B, was installed replacing the original design. This pier was expected to smooth the water surface by reducing the height of the fins but operation indicated that the condition was not improved appreciably. Information available since the model tests indicated that other factors in addition to the piers, contributed to the formation of the fins in the chute. Two features of the spillway now believed partly responsible for causing the fins are: (1) the nearly horizontal spillway section just below the crest; and (2) the convergence of the training-walls in the same region.

To check the training-wall design, water-surface profiles, Figure 17, were obtained for the maximum discharge of 56,000 second-feet. The measurements were made from the upstream end of the entrance channel to the stilling-basin along each training-wall and in the center of the spillway. These profiles are shown in Figure 17.

Spillway Crest Calibration

The spillway was calibrated for free flow over the crest. Discharges over the spillway were measured with a V-notch weir and the corresponding reservoir elevation was read with a point gage. The data thus obtained were plotted giving the curve of reservoir head versus spillway discharge, Figure 18. A curve of discharge coefficient versus head and the tail-water curve used in the stilling-basin design are also shown in the figure.

Model-prototype Comparison

Two photographs of the prototype operation are presented in this report together with the corresponding model photographs. Flow entering the model spillway is shown in Figure 19A with the prototype action shown in Figure 19B. Very close similarity is shown in the rough water surface caused by the interference of the spoil bank on the left side of the entrance channel. Figure 20 shows model and prototype flow in the spillway chute. The similarity of performance is again evident. The three fins are present, but their magnitude in the prototype is greater than indicated by the model, probably due to insufflation of air at the higher velocities in the prototype.

Table 1

SUMMARY OF STILLING-BASIN TESTS
Original Design

Test No.	Step No.	End sill No.	End sill Dist. from step	Misc.	Results
1	A	-	-	-	Jump too far downstream in stilling-pool. Side eddy located between end of stilling-pool and left bank. Heavy scour.
2	B	-	-	-	Jump farther downstream than in Test 1. Side eddy unchanged. Scour as in prevous test.
3	C	-	-	-	Jump farther upstream than in Test 1. Eddy as before. Scour unchanged.
4	D	A1	120'	-	Jump farther upstream than previous tests without sill. Side eddy less pronounced.
5	D	A2	120'	-	Jump farther downstream than in Test 4. Side eddy unchanged.
6	D	A2	110'	-	Jump farther upstream by 10' than in Test 5. Other conditions unchanged.
7	D	A3	120'	-	Jump farther downstream than with any of previous sills tried. Side eddy as before.
8	D & F	A3	120'	Teeth between steps	Unsatisfactory.
9	D	A3	120'	Spreaders in chute	Results same as in Test 7 without spreaders.

Table 2

SUMMARY OF STILLING-BASIN TESTS
First Revision

Test No.	Step No.	End sill No.	End sill Dist. from step	Misc.	Results
10	C	B	120'	-	Jump too far downstream, but upstream farther than tests without sill. Moderate scour in river channel.
11	D	B	120'	-	Jump location slightly upstream over Test 10. Scour about the same.

Second Revision

Test No.	Step No.	End sill No.	End sill Dist. from step	Misc.	Results
12	C	A4	120'	-	Jump location best yet attained. Eddy at left bank now negligible.
13	A	A4	120'	-	Conditions changed very little from Test 12. Scour less than any of previous tests.
14	A	A4	120'	3 intermediate sills installed	Jump unsatisfactory because unstable. Scour slight.
15	A	A2, 3, 4, 5	110', 120'	-	Jump farther downstream with lower sills and with downstream position of sill. Scour slight.
16	A	C2, 3, 4, 5	110', 120'	-	Results practically the same as Test 15.
17	A C D E	C5	120'	Fillets in pool and lower end of chute	Higher steps resulted in the jump being farther upstream as with the higher sills. Scour slight.
18	E	F7, 8, 9, 10	110', 120'	Fillets in pool and lower end of chute	Higher sills resulted in the jump being farther upstream as in Tests 15 and 16. Scour slight.

Table 3

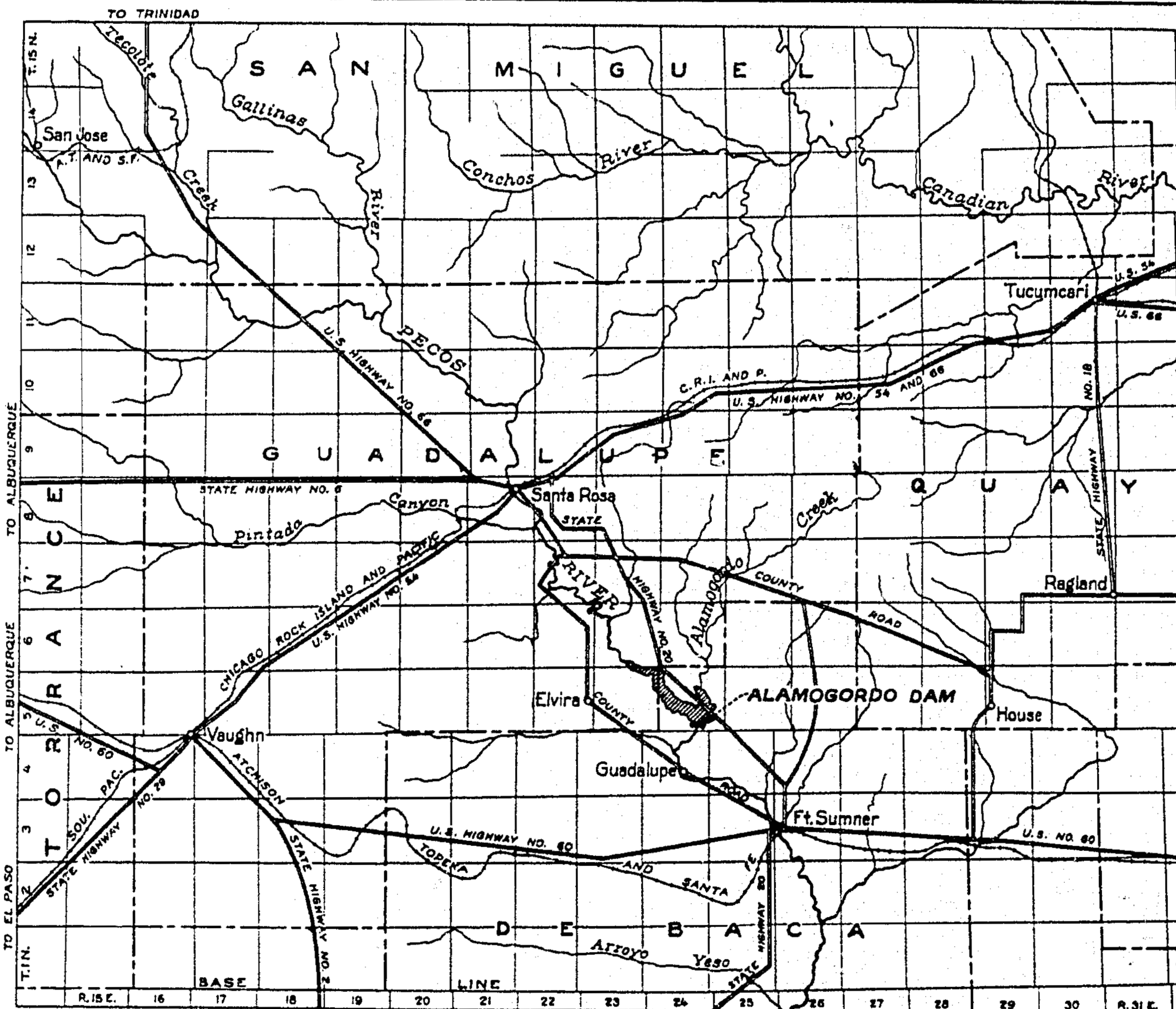
SUMMARY OF STILLING-BASIN TESTS
Third Revision

Test No.	Step No.	End sill		Misc.	Results
		No.	Dist. from step		
19	E	F8	110'	Fillets in pool and lower end of chute	Jump located farther upstream than any previous tests. Scour slight. Side eddy present.
20	E	F9	110'	Fillets in pool and lower end of chute	Jump moved upstream some over Test 19. Scour unchanged. Side eddy improved.
21	E	F10	110'	Fillets in pool and lower end of chute	Jump upstream over Test 20. Most satisfactory conditions yet attained. Scour slight as in two previous tests. Side eddy negligible.

Recommended Design

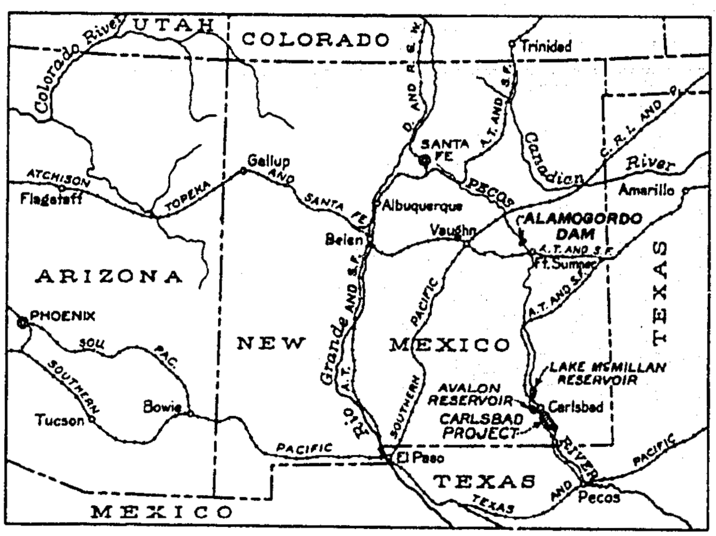
Test No.	Step No.	End sill		Misc.	Results
		No.	Dist. from step		
22	E	F10	110'	Fillets in pool and lower end of chute	Results unchanged from that of Test 21.

SPECIFICATIONS No. 660 FIGURE 1



VICINITY MAP

5 0 5 10 15 20
SCALE OF MILES



INDEX MAP

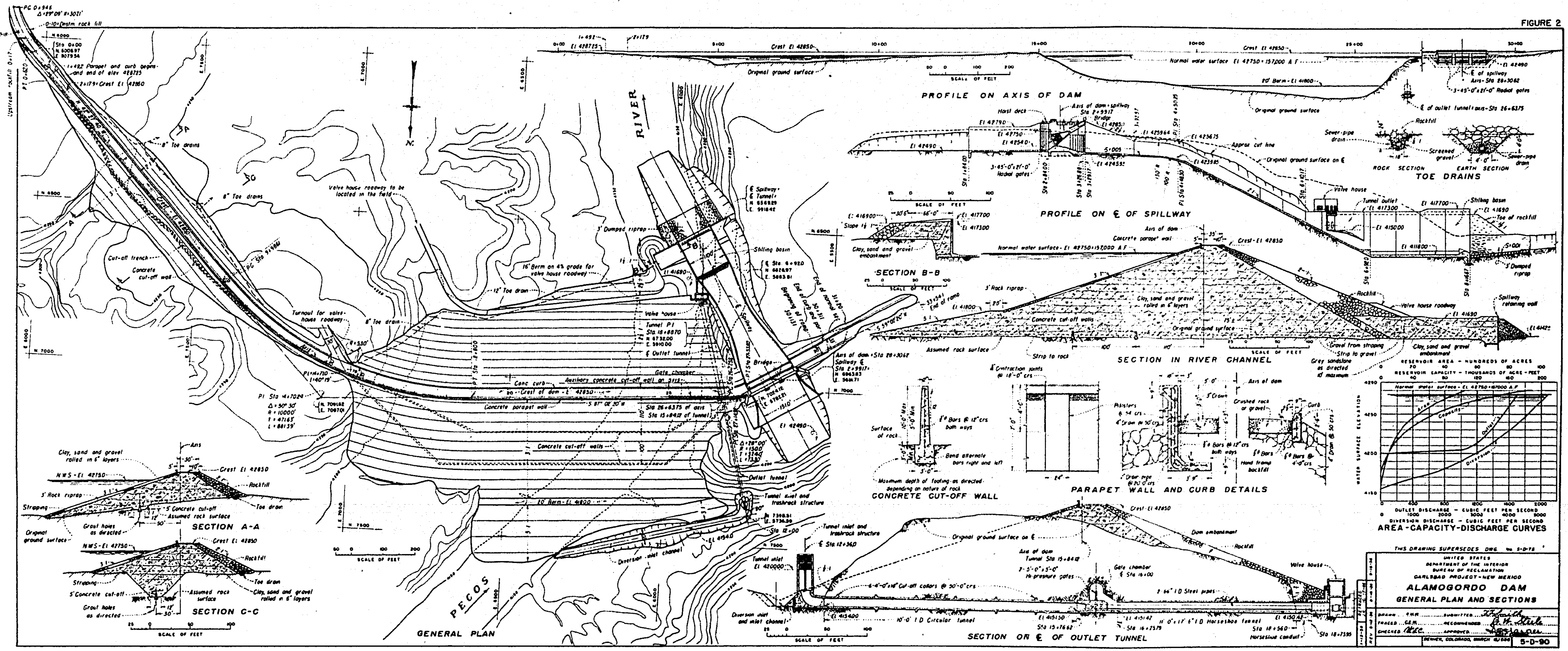
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CARLSBAD PROJECT—NEW MEXICO

ALAMOGORDO DAM
LOCATION MAP

DRAWN: D.R.B.	SUBMITTED: B.W. Steele
TRACED: D.C.K.	RECOMMENDED: W.H. Nalder
CHECKED: ALS	APPROVED: A.F. Moster

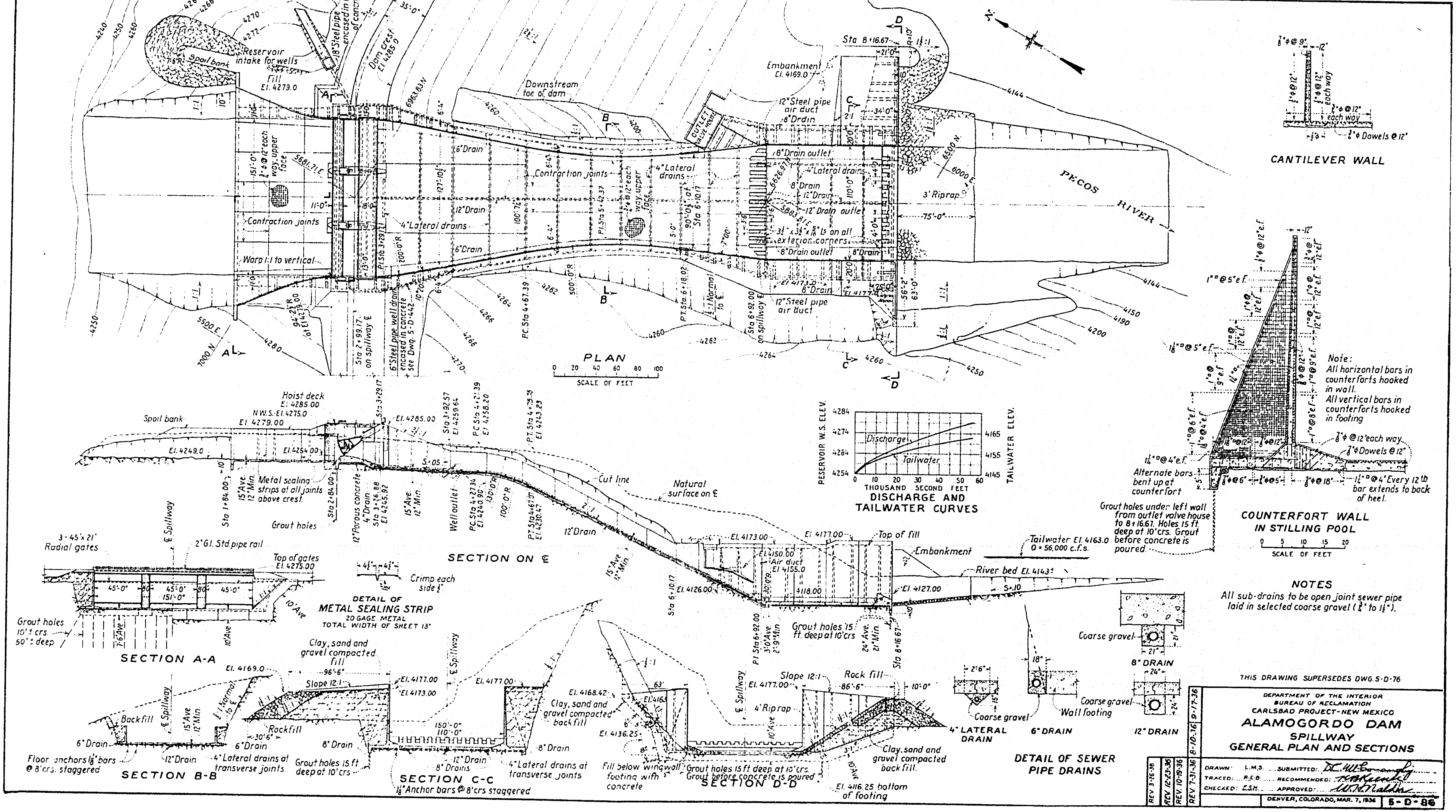
27861	DENVER, COLORADO, OCT. 31, 1935	5-D-71

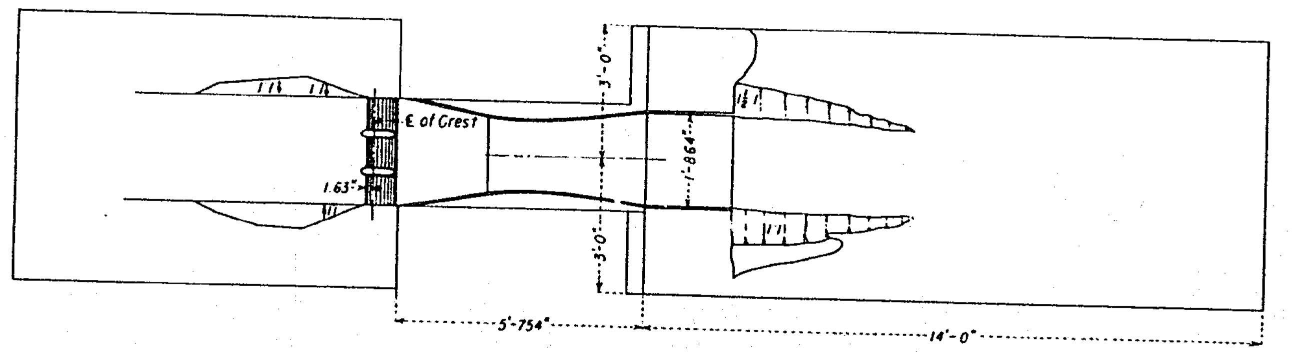
FIGURE 2



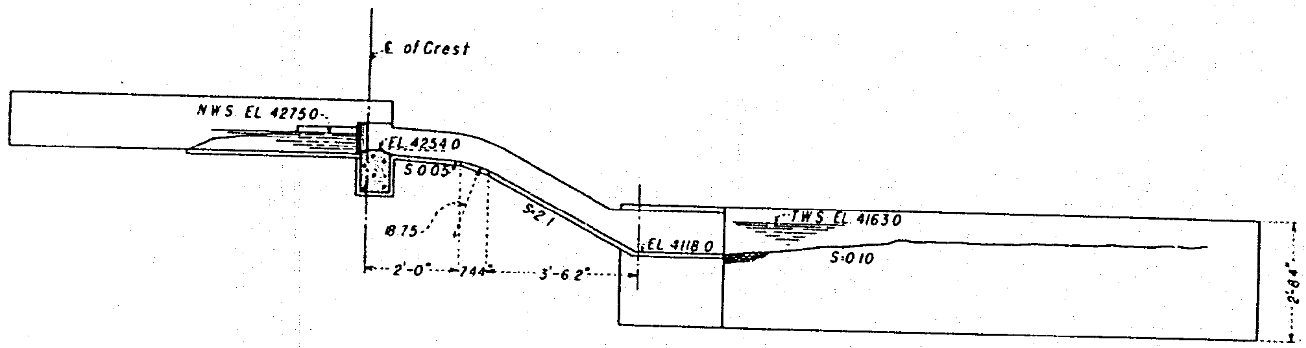
PROFILE ON AXIS OF DAM
PROFILE ON ℄ OF SPILLWAY
TOE DRAINS
ROCK SECTION
EARTH SECTION
SECTION B-B
SECTION IN RIVER CHANNEL
CONCRETE CUT-OFF WALL
PARAPET WALL AND CURB DETAILS
AREA-CAPACITY-DISCHARGE CURVES
SECTION A-A
SECTION C-C
GENERAL PLAN
PECOS
RIVER
SECTION ON ℄ OF OUTLET TUNNEL
Crest El 4285.0
Normal water surface El 4275.0 - 157,000 A.F.
Original ground surface
Valve house
Stilling basin
Rockfill
Clay, sand and gravel rolled in 6" layers
THIS DRAWING SUPERSEDES DWG. No. 5-D-75
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CARLSBAD PROJECT - NEW MEXICO
ALAMOGORDO DAM
GENERAL PLAN AND SECTIONS
DENVER, COLORADO, MARCH 15, 1936
5-D-90

FIGURE 3


PLAN
SCALE OF FEET
PECOS RIVER
Reservoir intake for wells
Spoil bank
Dam crest El. 4285.0
Downstream toe of dam
Contraction joints
4" Lateral drains
6" Drain
12" Drain
Warp 1:1 to vertical
Embankment El. 4169.0
12" Steel pipe air duct
8" Drain outlet
12" Drain outlet
3' Riprap
CANTILEVER WALL
COUNTERFORT WALL IN STILLING POOL
Note: All horizontal bars in counterforts hooked in wall. All vertical bars in counterforts hooked in footing
SECTION ON ℄
Hoist deck El. 4285.00
N.W.S. El. 4275.0
Cut line
Natural surface on ℄
Top of fill
Tailwater El. 4163.0 Q = 56,000 c.f.s.
River bed El. 4143±
DISCHARGE AND TAILWATER CURVES
RESERVOIR W.S. ELEV.
TAILWATER ELEV.
THOUSAND SECOND FEET
Discharge
Tailwater
SECTION A-A
3 - 45'x 21' Radial gates
2" G.I. Std pipe rail
Top of gates El. 4275.00
Grout holes 10'± crs 50'± deep
DETAIL OF METAL SEALING STRIP
20 GAGE METAL TOTAL WIDTH OF SHEET 13"
Crimp each side ⅛"
SECTION B-B
SECTION C-C
SECTION D-D
NOTES
All sub-drains to be open joint sewer pipe laid in selected coarse gravel (¾" to 1½").
DETAIL OF SEWER PIPE DRAINS
4" LATERAL DRAIN
6" DRAIN
8" DRAIN
12" DRAIN
THIS DRAWING SUPERSEDES DWG. 5-D-76
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CARLSBAD PROJECT-NEW MEXICO
ALAMOGORDO DAM
SPILLWAY
GENERAL PLAN AND SECTIONS
DENVER, COLORADO, MAR. 7, 1936
5-D-86

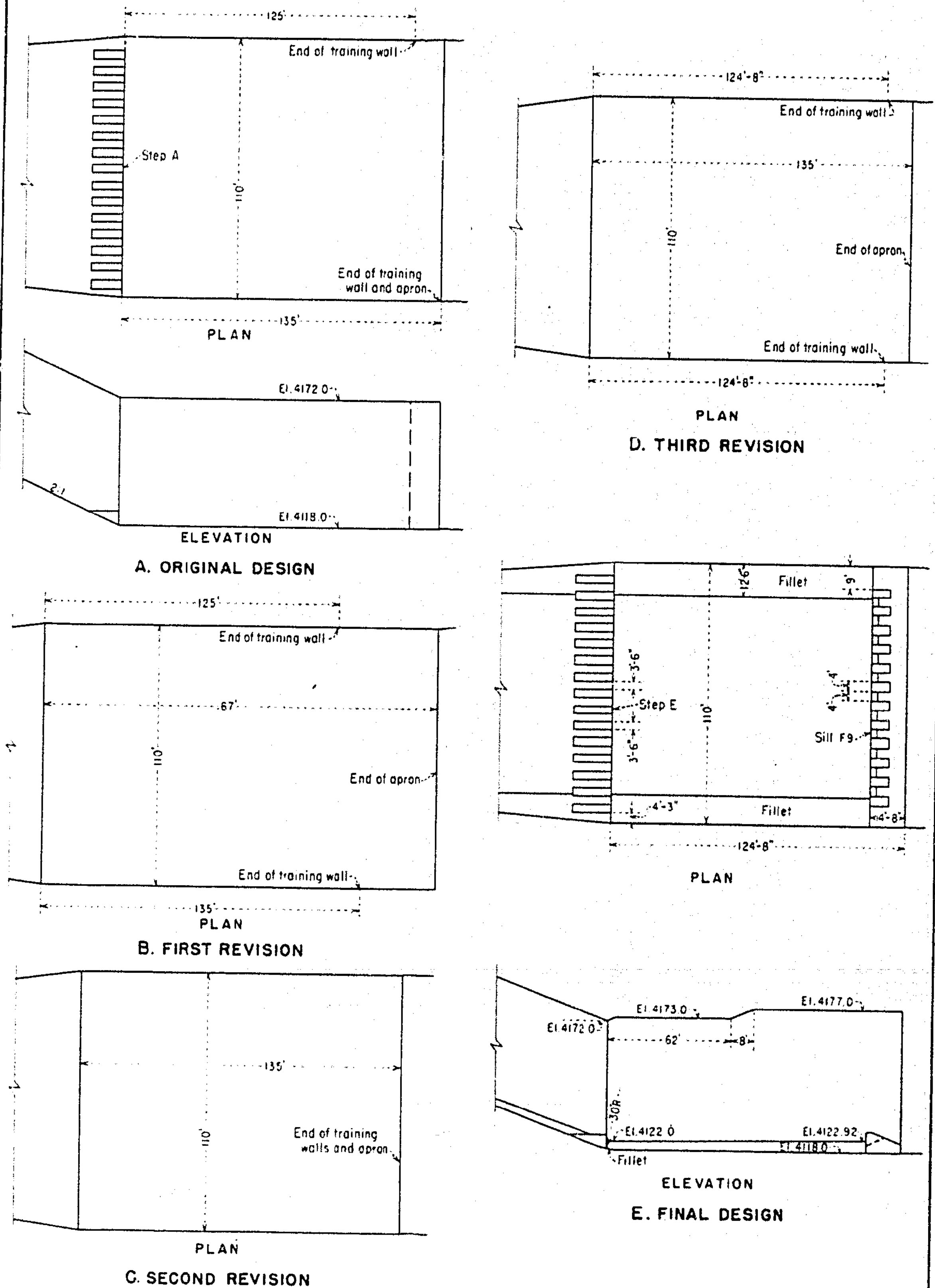


PLAN



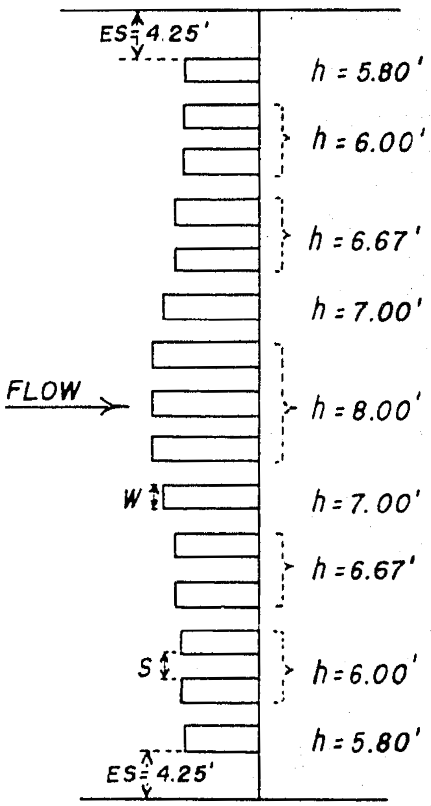
ELEVATION

ALAMOGORDO DAM
FINAL DESIGN 1:64 MODEL



ALAMOGORDO DAM

STILLING POOL DETAILS



PLAN - STEP D

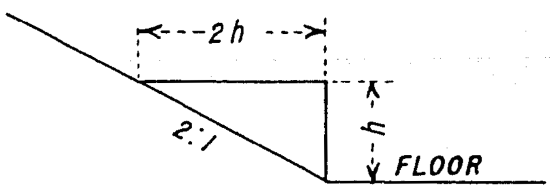
DIMENSIONS OF STEPS

STEP	h	W	S
A	6'	3.5'	3.5'
B	5'		
C	7'		
D	VARIES		
E	8'		
F*	2.67'		

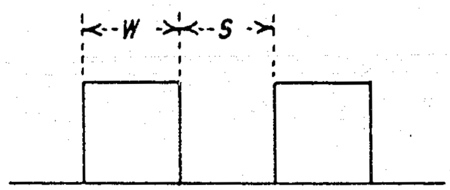
*IN SPACES BETWEEN STEPS

NOTE

Location, number, width, and spacing of steps A, B, C, and E same as step D.



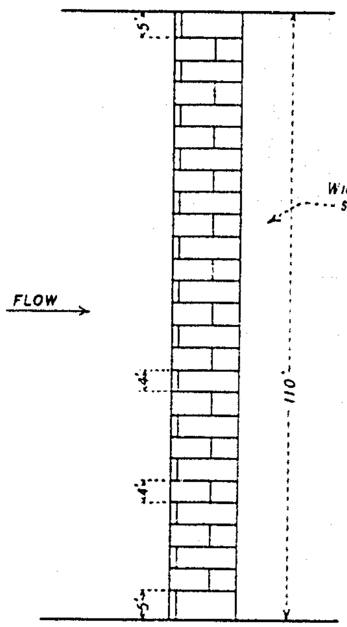
PROFILE



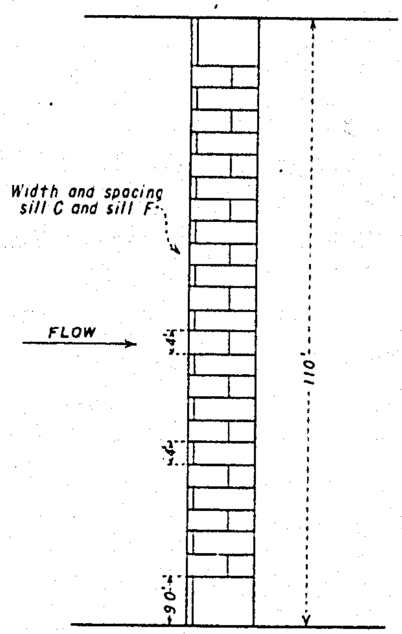
END VIEW

ALAMOGORDO DAM
STEP DETAILS

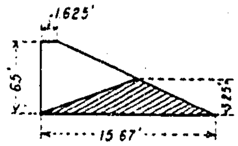
7



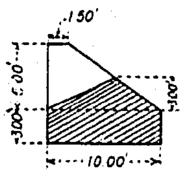
PLAN



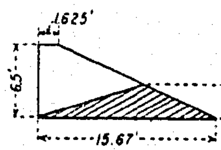
PLAN



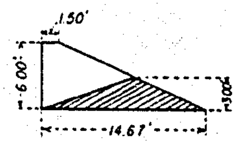
SILL A



SILL B

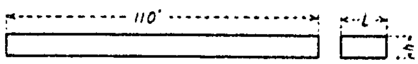


SILL C



SILL F

REHBOCK SILLS



RECTANGULAR SILL

DIMENSIONS OF RECTANGULAR SILL

SILL No.	h	L
1	5.00'	15.67'
2	2.58'	
3	1.33'	
4	3.33'	
5	3.67'	
7	1.00'	14.67'
8	2.00'	
9	3.00'	
10	4.00'	

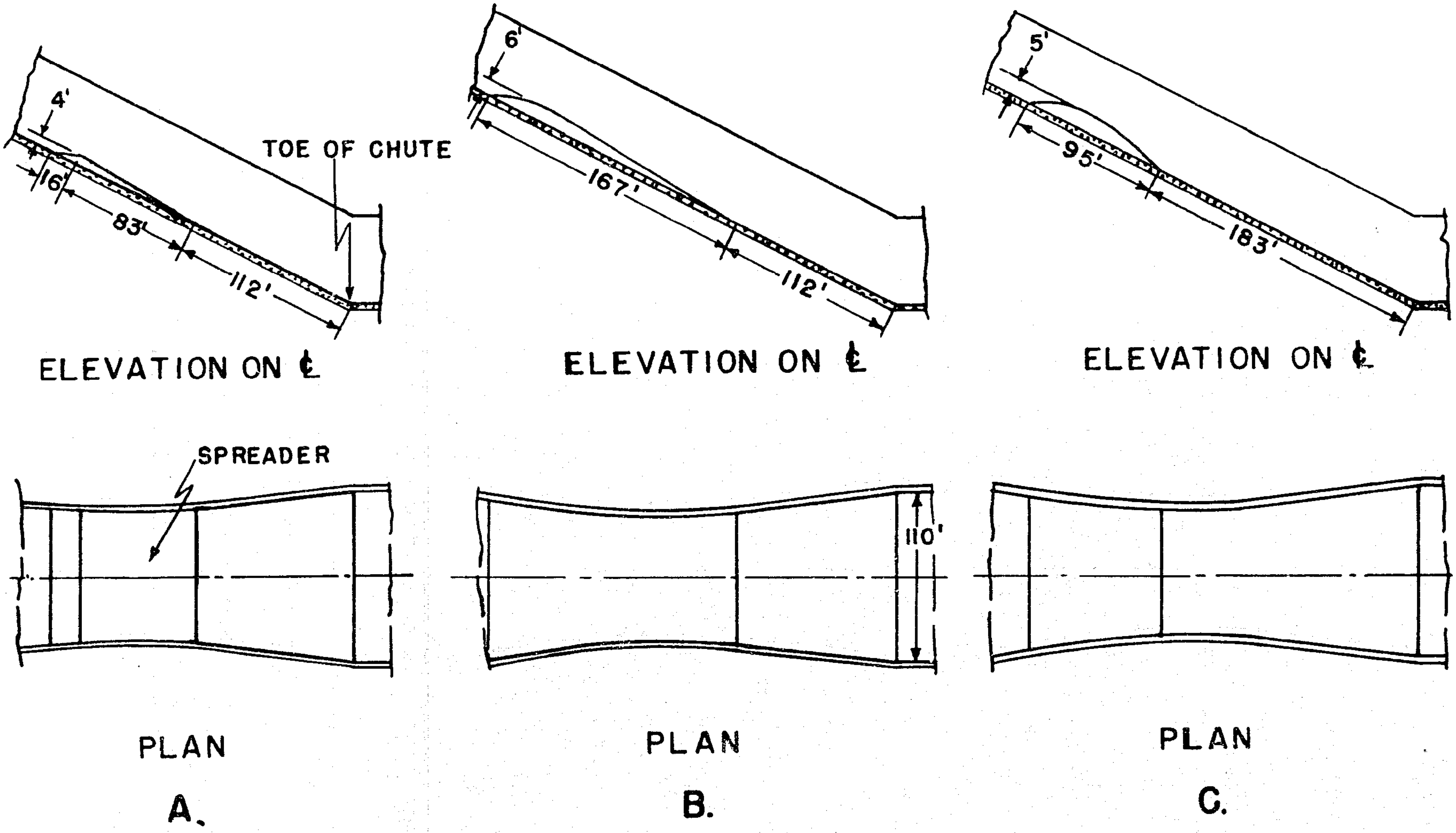
NOTE

Solid rectangular sill No. 1 through No 5 used in combination with rehbock sill A and C to provide height adjustment.
Rectangular sill No 7 through No. 10 used in combination with rehbock sill F.

ALAMOGORDO DAM
SILL DETAILS

8

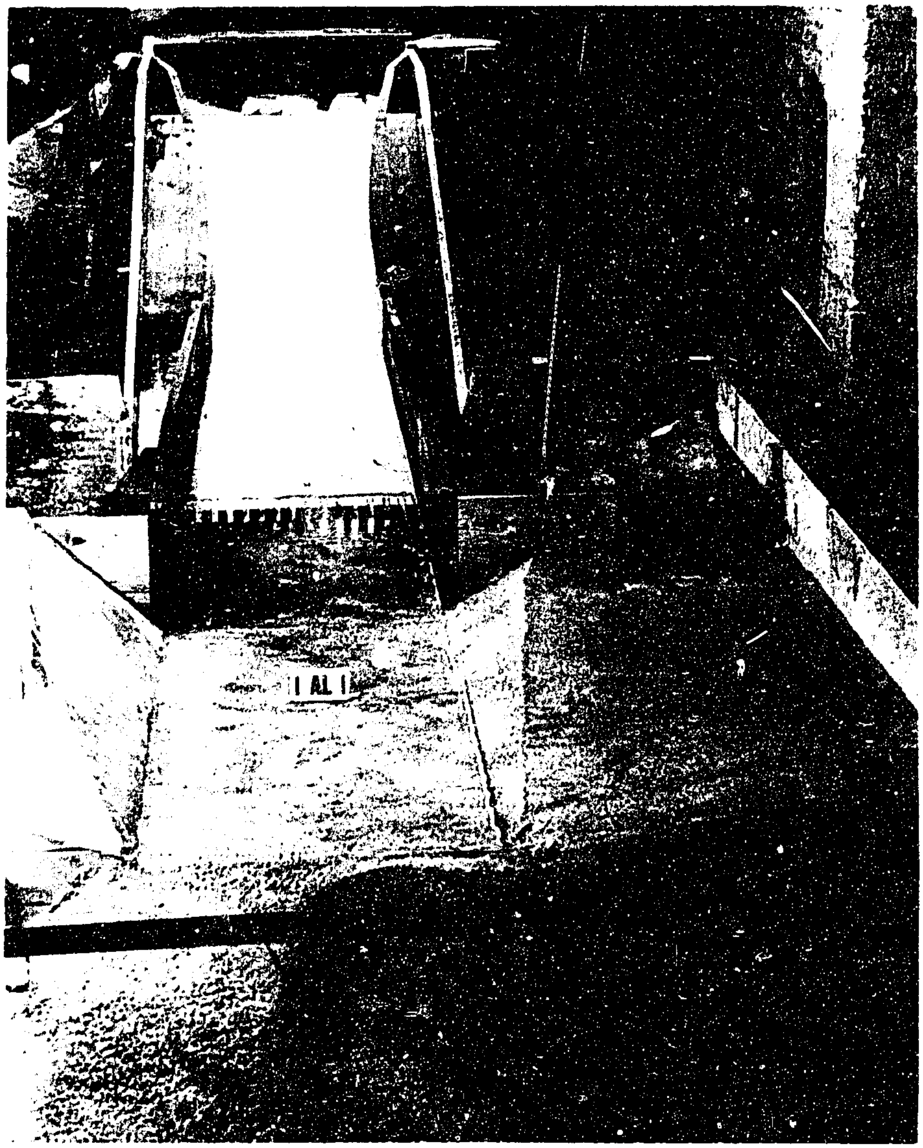
FIGURE 8



ALAMOGORDO DAM

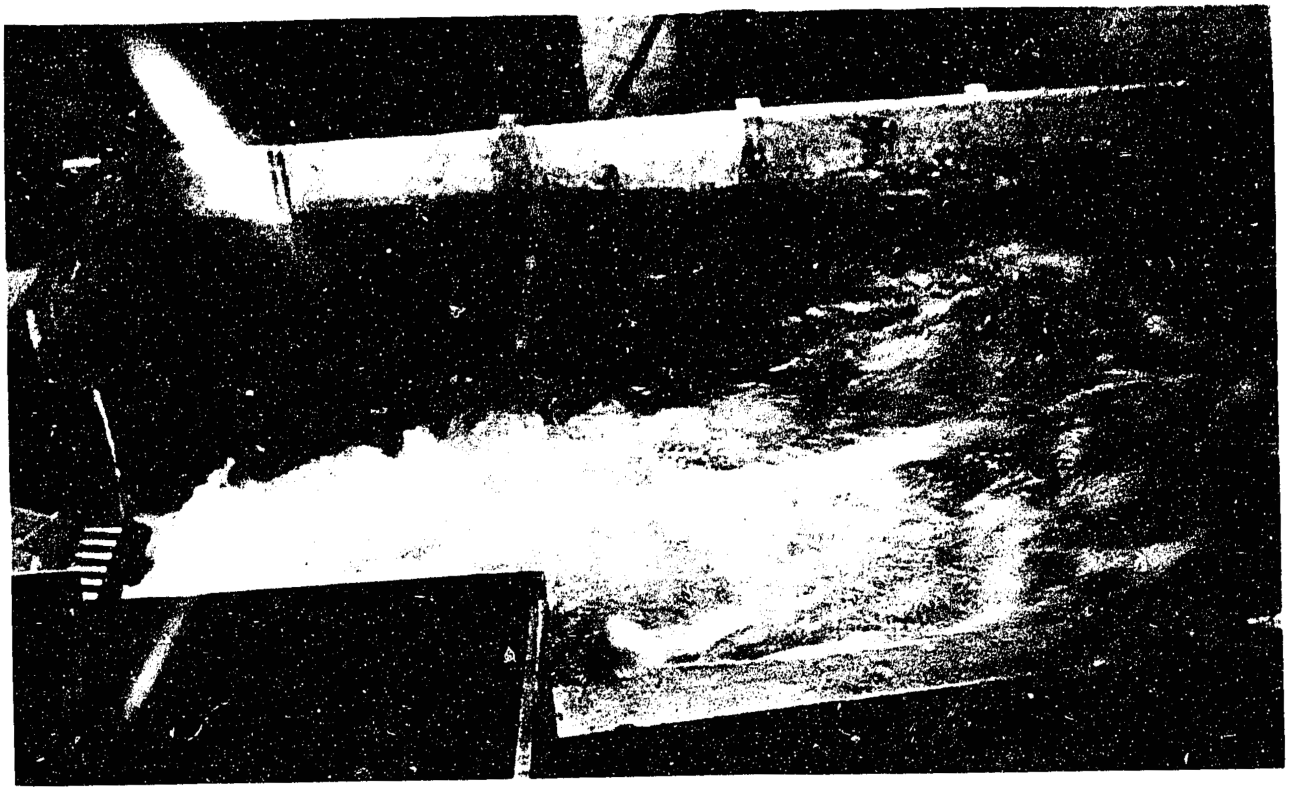
SPREADERS IN SPILLWAY CHUTE

Figure 9

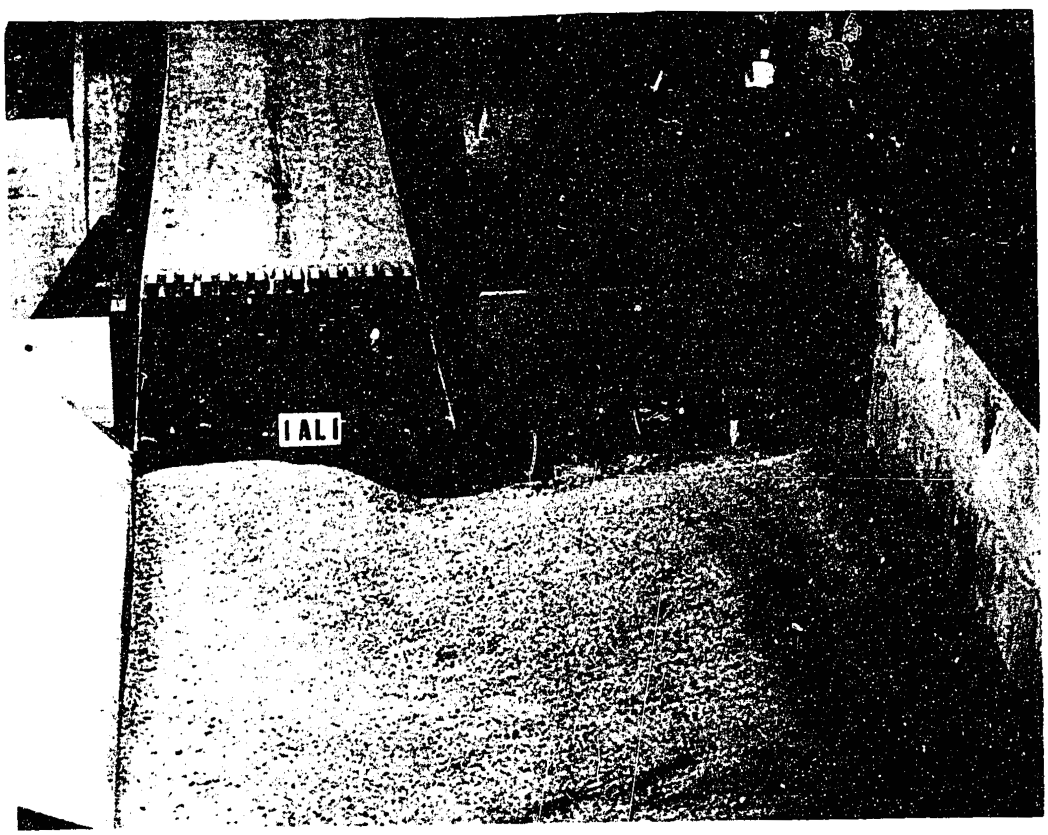


Original Design - Test 1.

ALAMOGORDO DAM, 1:64 MODEL

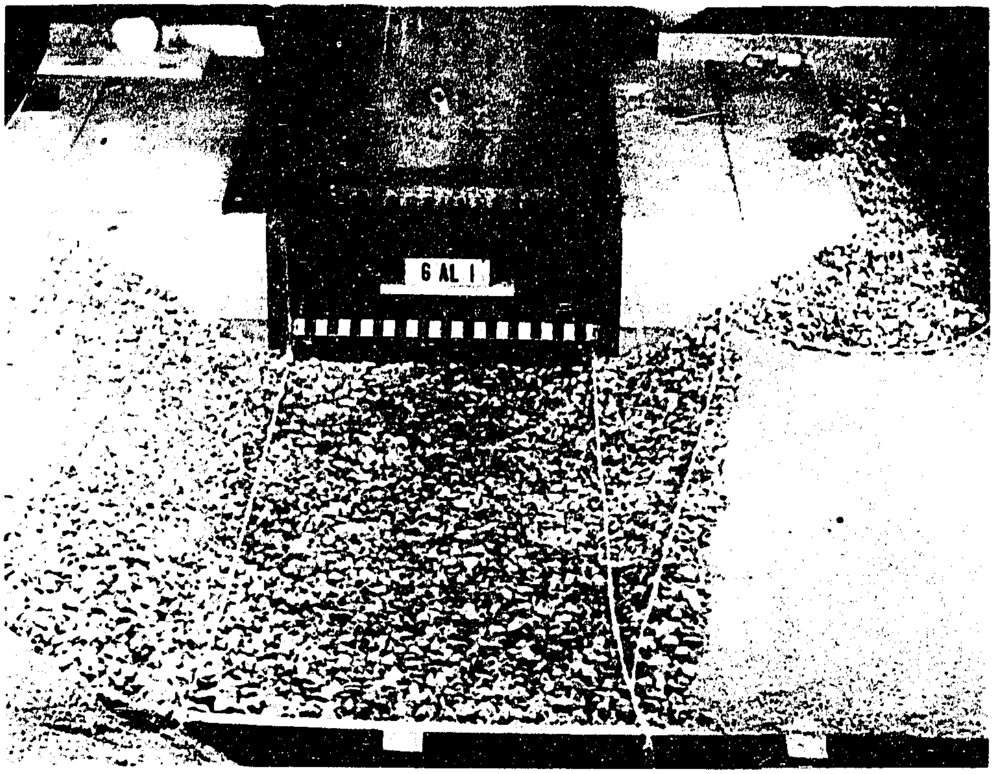


A. Discharge 56,000 second-feet. Tailwater 4163 feet.

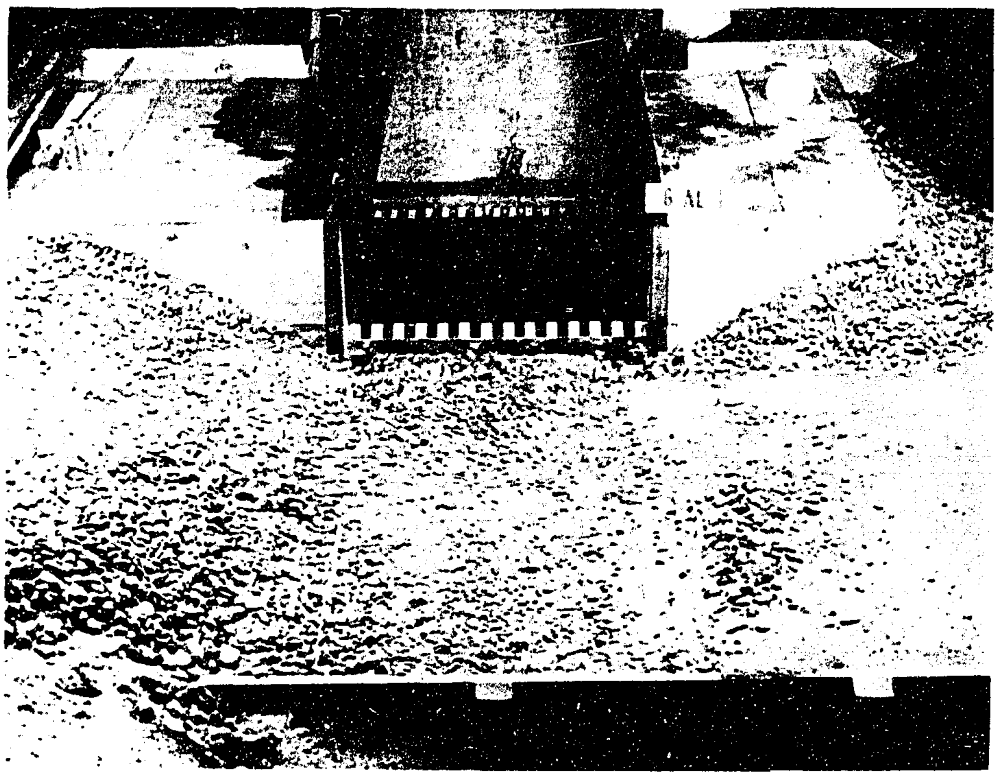


B. Scour after 2 hrs. operation at 56,000 second-feet.

TEST 1 - ALAMOGORDO DAM, 1:64 MODEL



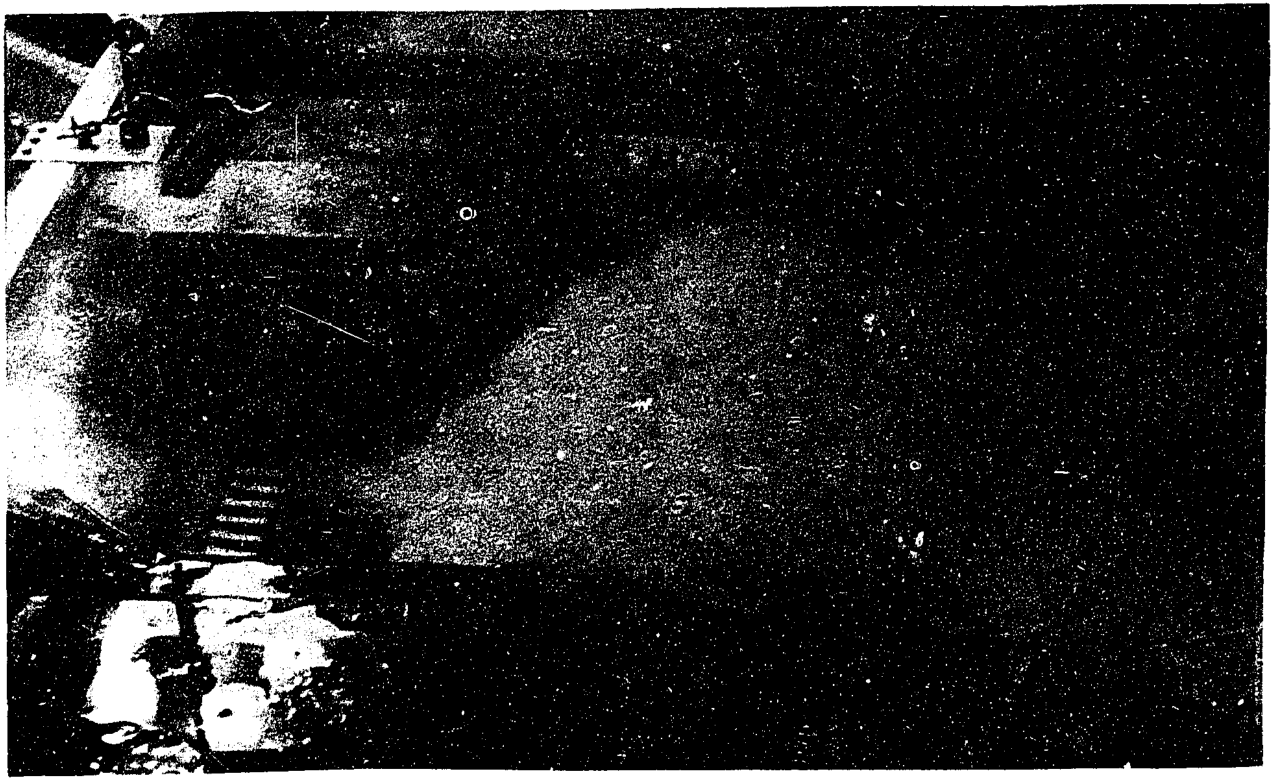
A. River channel before operating.



B. Scour after 1 hr. operation at 56,000 second-feet.

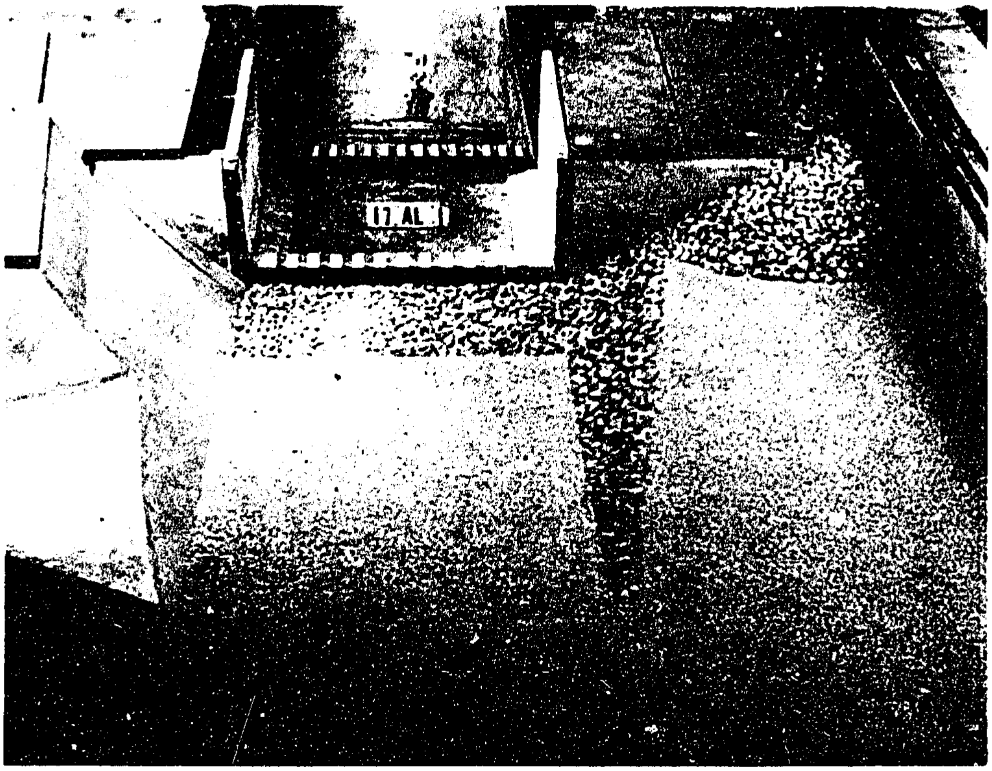
TEST 13 - ALAMOGORDO DAM, 1:64 MODEL

A. Test 13 Discharge 56,000 second-feet.
Tailwater 4163 feet.

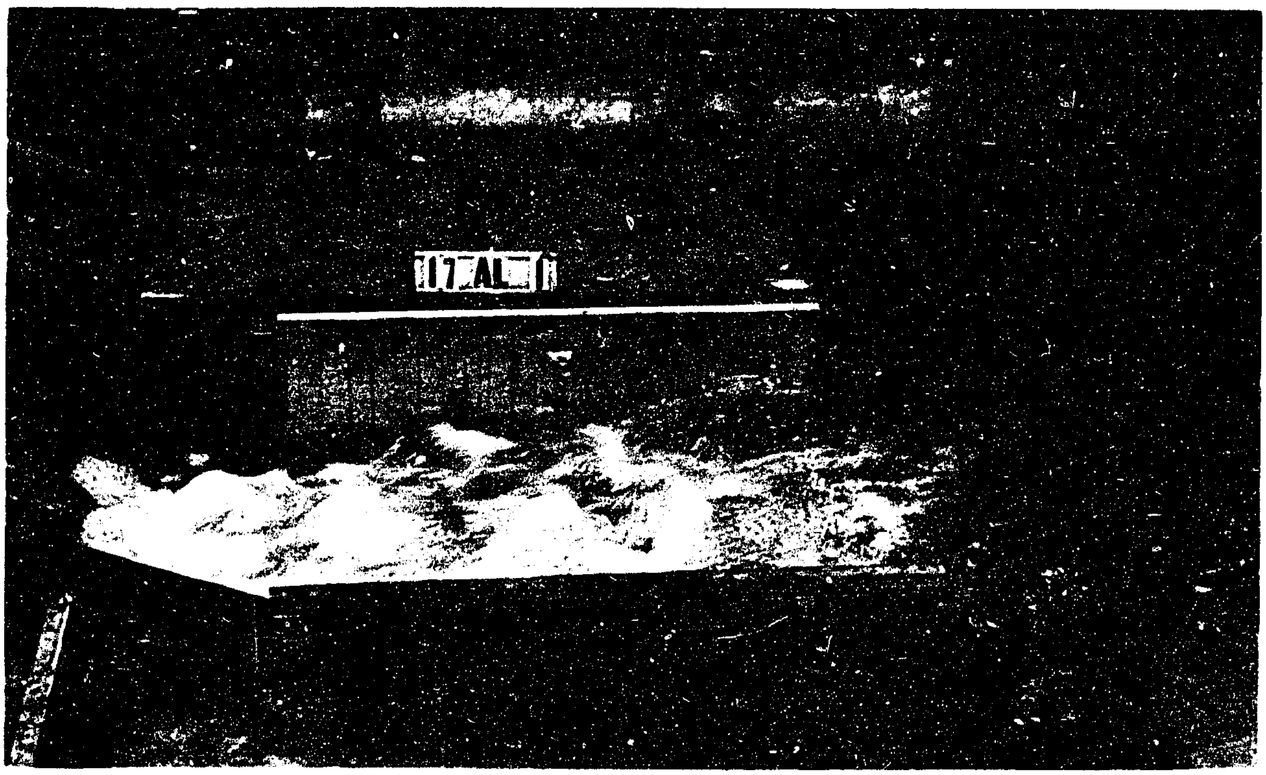


Test 14 Discharge 56,000 second-feet.
Tailwater 4163 feet.

ALAMOGORDO DAM, 1:64 MODEL

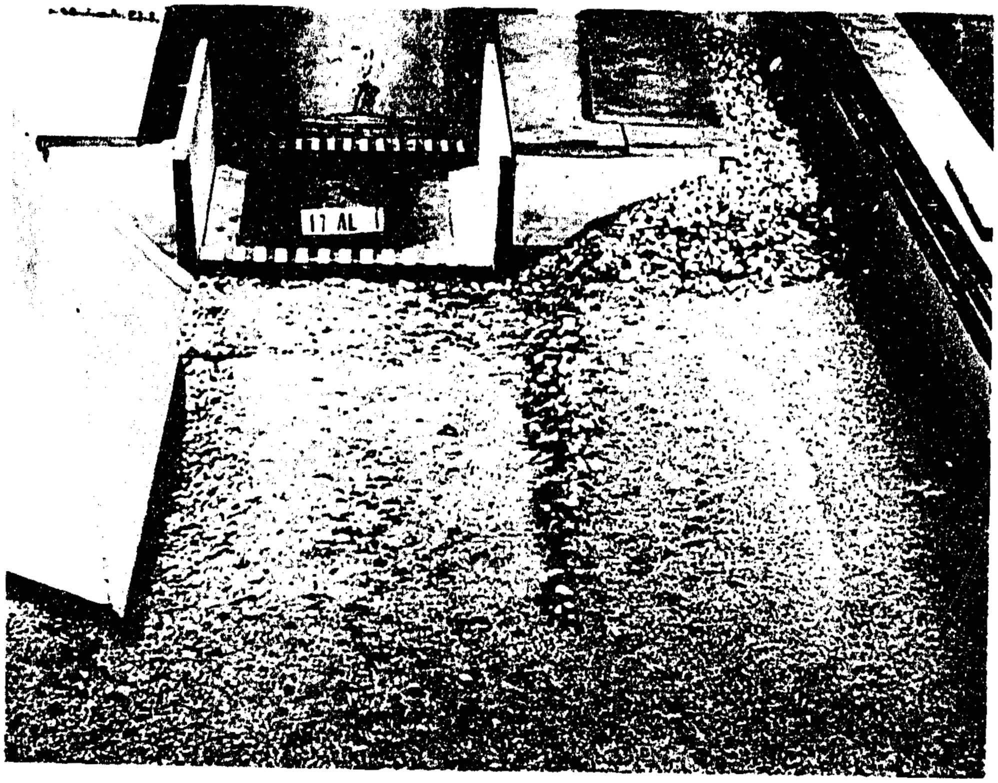


A. River channel before operating.

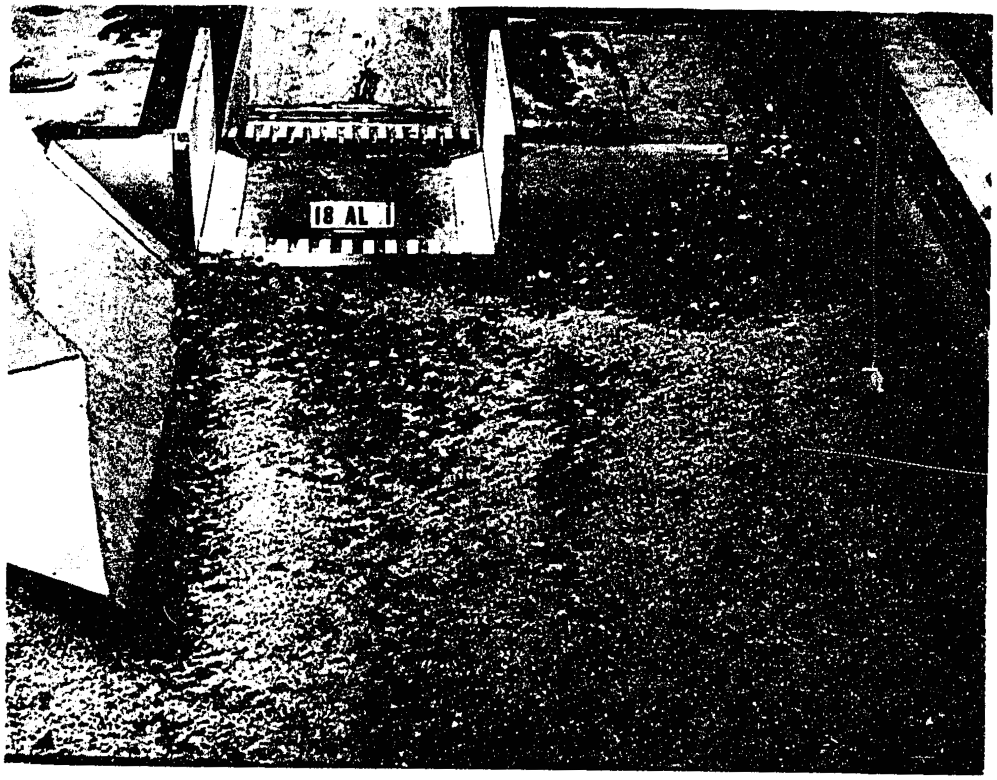


B. Discharge 28,000 second-feet. Tailwater 4157.2 feet.

TEST 22 - ALAMOGORDO DAM, 1:64 MODEL

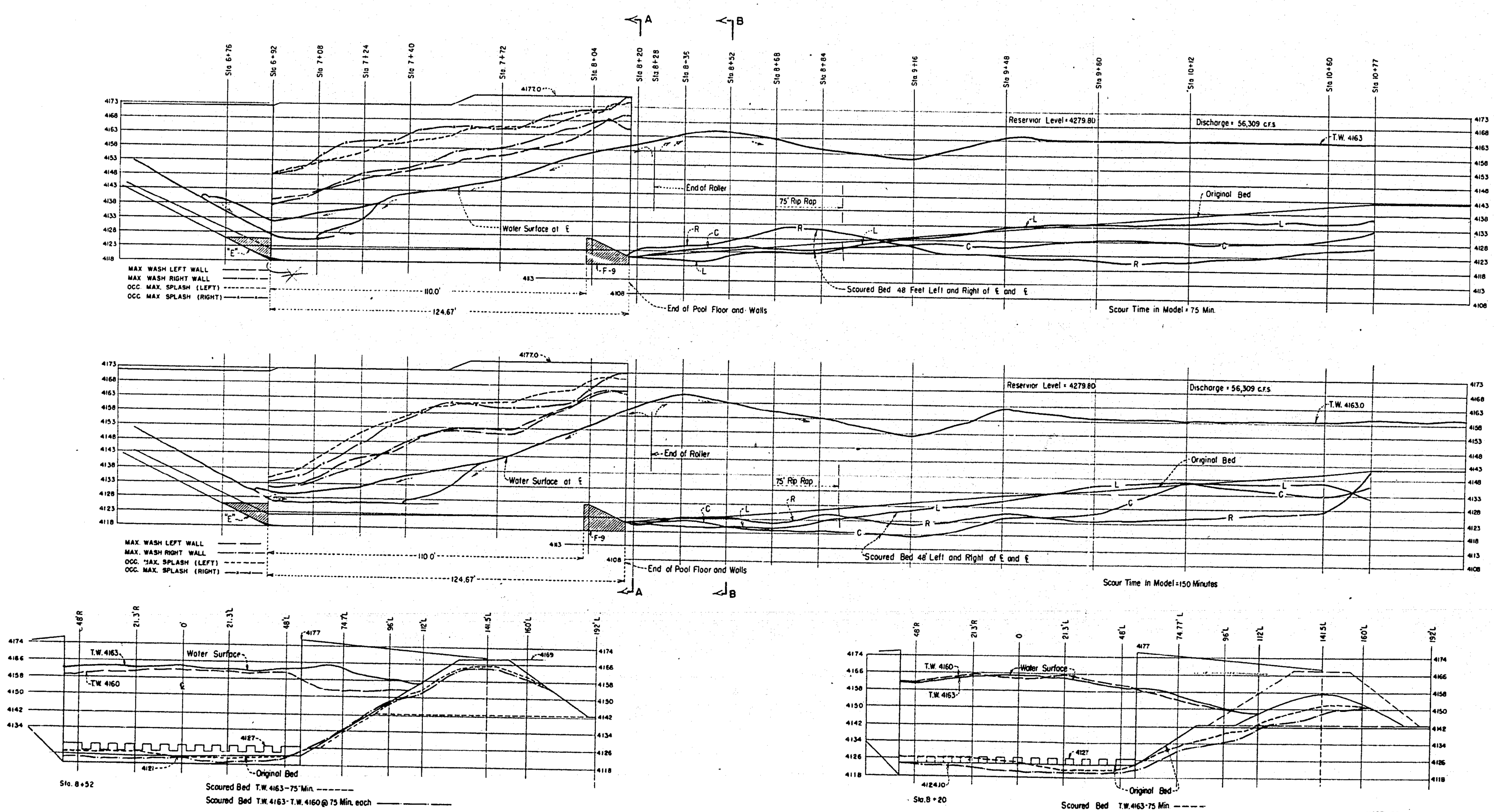


A. Scour after 1 hr. operation at 28,000 second-feet.



B. Scour after 1 hr. operation at 56,000 second-feet.

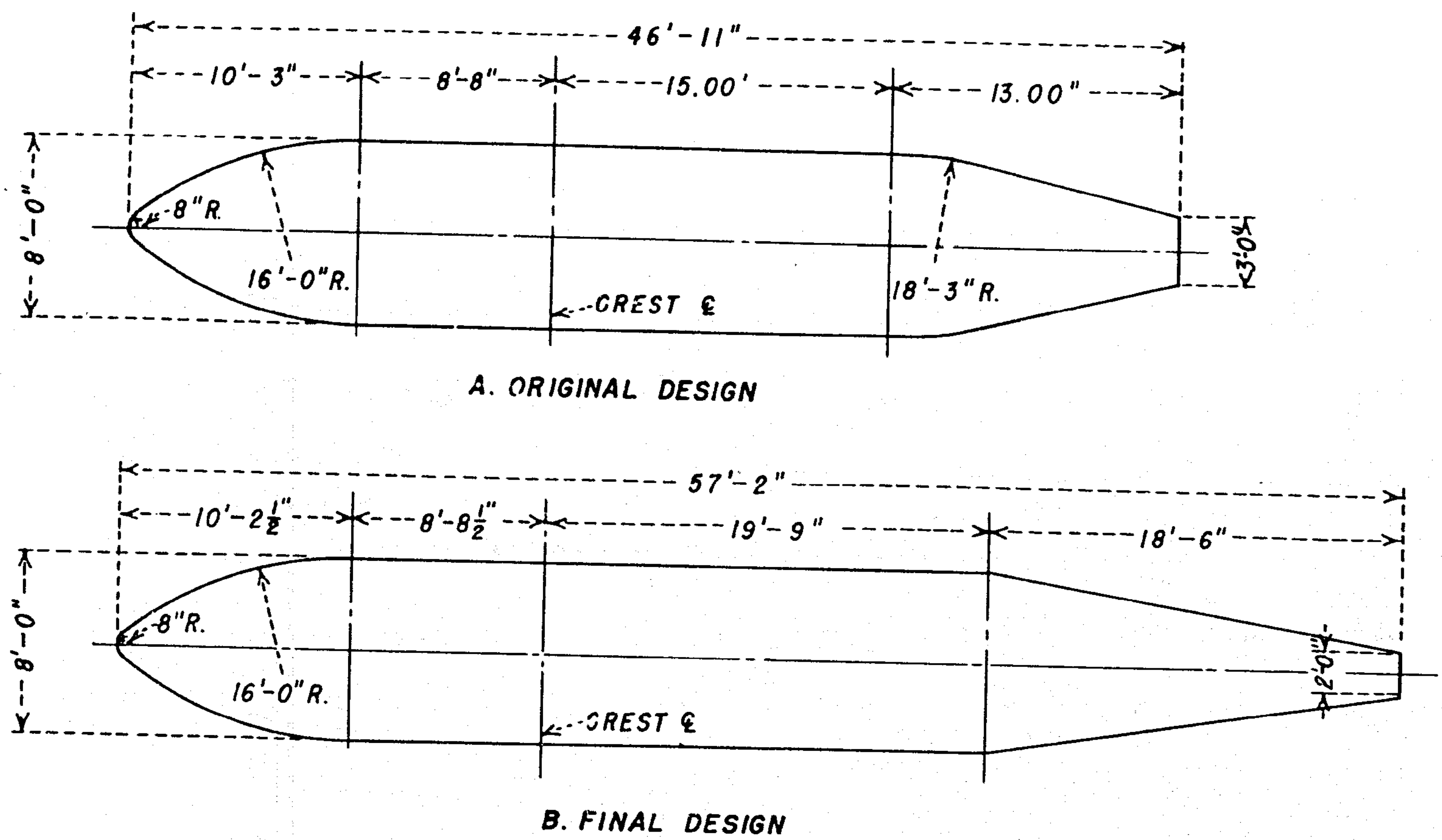
TEST 22 - ALAMOGORDO DAM, 1:64 MODEL



SECTION A-A

SECTION B-B

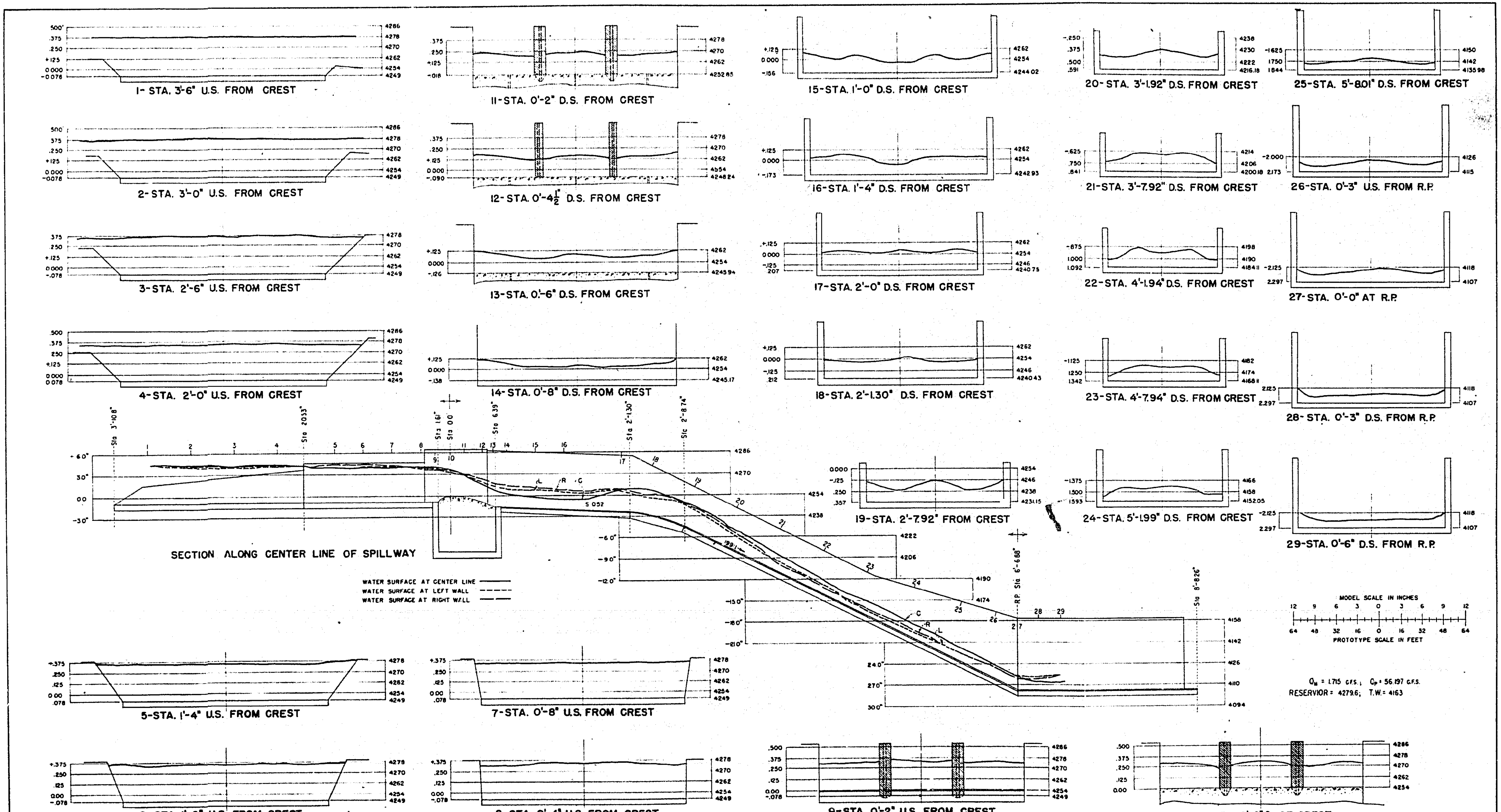
FINAL DESIGN
STILLING POOL WATER SURFACE AND SCOUR PROFILES
ALAMOGORDO DAM



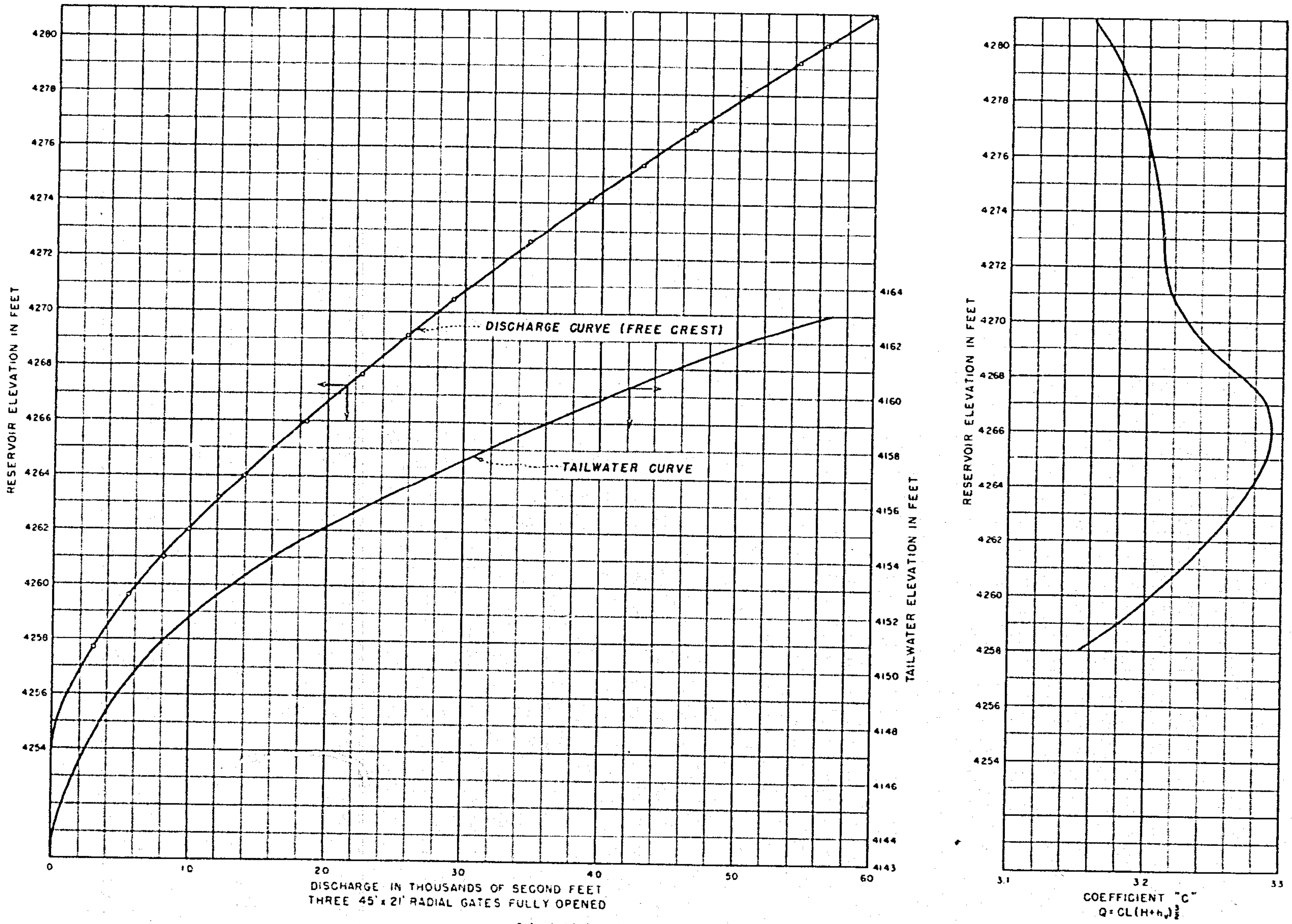
ALAMOGORDO DAM
PIER SECTION

FIGURE 16

8



FINAL DESIGN
SPILLWAY WATER SURFACE PROFILES
ALAMOGORDO DAM

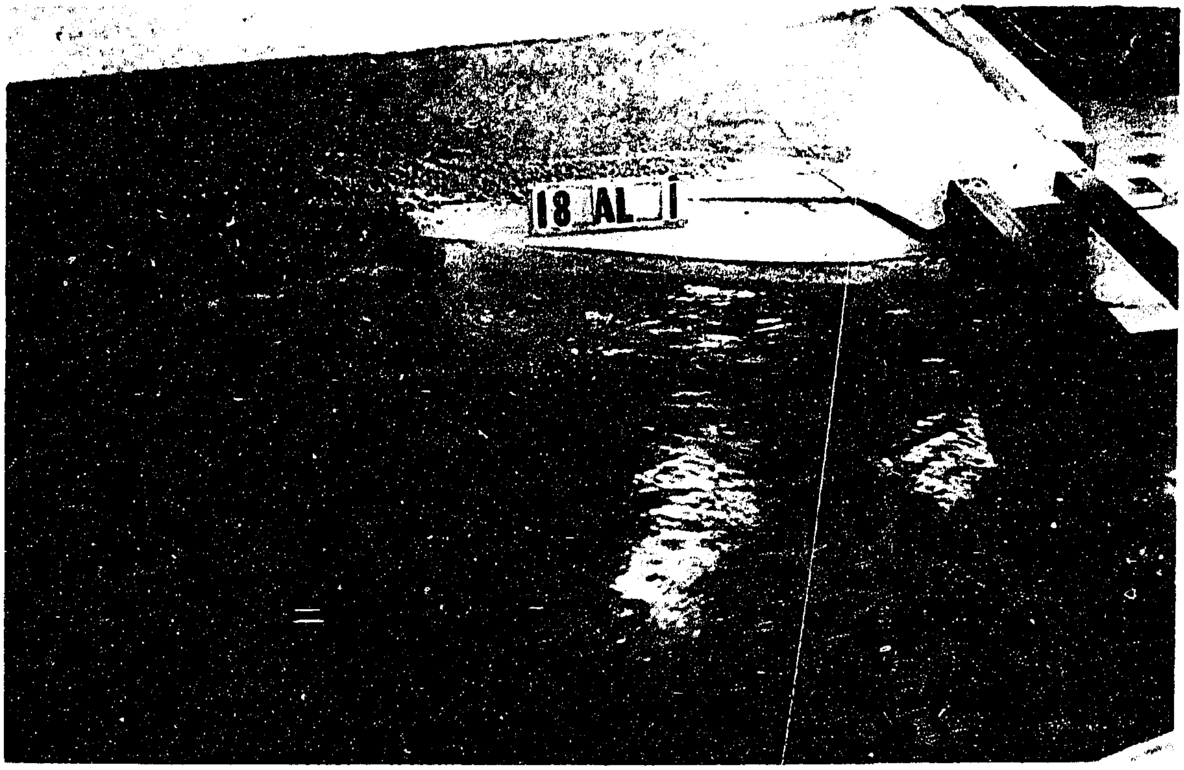


ALAMOGORDO DAM
SPILLWAY DISCHARGE CAPACITY

FIGURE 18

8

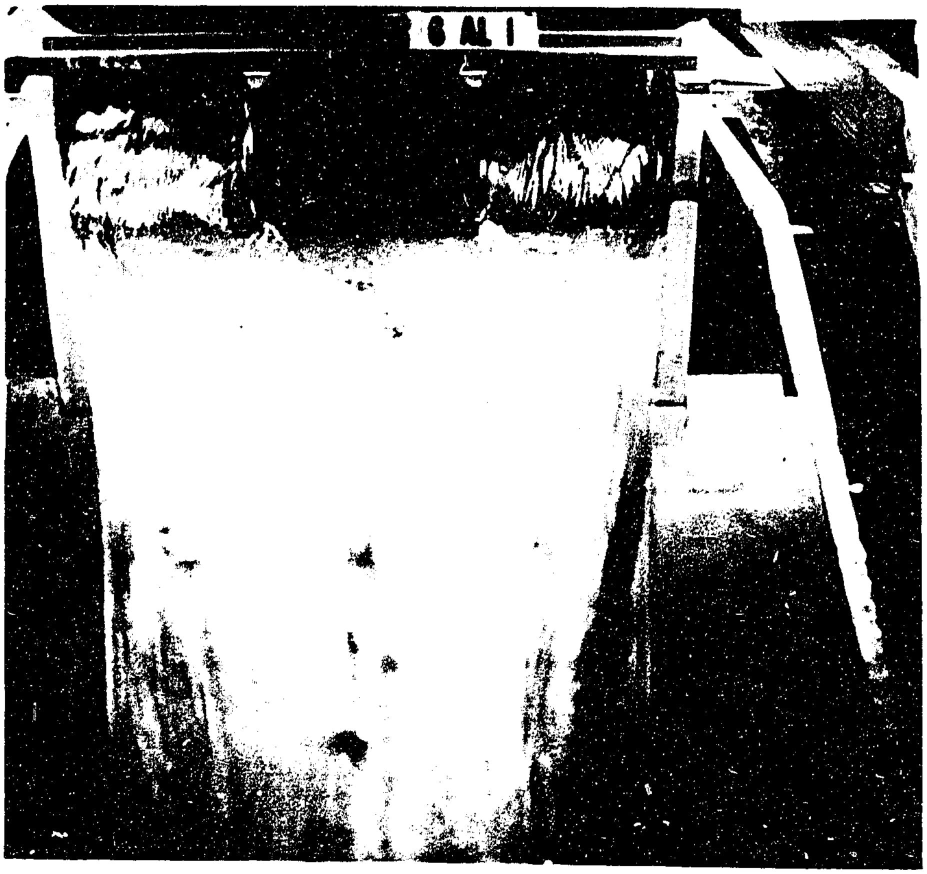
Figure 19



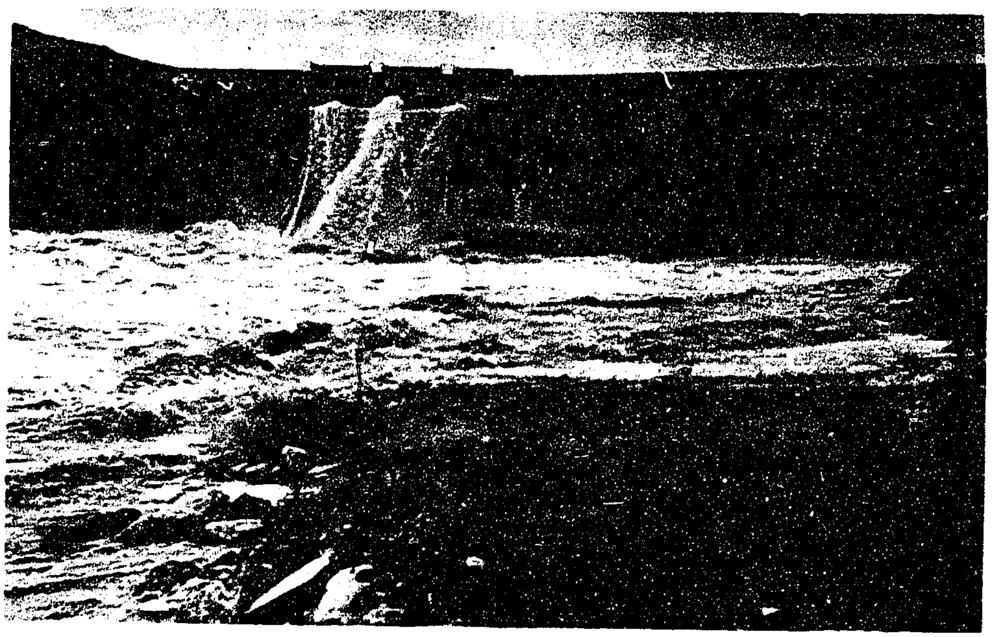
A. Model discharge of 56,000 second-feet.

B. Prototype of discharge of 42,000 second-feet.

ALAMOGORDO DAM. MODEL-PROTOTYPE
COMPARISON OF FLOW ENTERING SPILLWAY



A. Model discharge of 56,000 second-feet.



B. Prototype discharge of 42,000 second-feet.

ALAMOGORDO DAM. MODEL-PROTOTYPE
COMPARISON OF FLOW IN SPILLWAY